

Lead and Copper Corrosion Control

The reduction of lead and copper concentrations in public water supplies has become one of the foremost issues in water treatment.

Since the passage of the Safe Drinking Water Act (SDWA) in 1974, the EPA has been charged to protect public health by setting standards for public water supplies. At the heart of the SDWA are set maximum contaminant levels (MCLs) for various contaminants found in water supplies. In 1986, amendments to the SDWA were signed into law that included provisions barring the use of lead bearing materials in the installation or repair of public water systems. On June 7, 1991, the EPA published the final regulations for lead and copper in the *Federal Register*. The new rule replaced the interim MCL for lead with a treatment technique requirement. The new rule establishes maximum contaminant level goals for lead and copper along with treatment techniques that include optimum corrosion control treatment, source water treatment, public education, and lead service line replacement. The primary focus here will be on the various treatment techniques available to reduce lead and copper solubility and maintain compliance with the portion of the lead copper rule dealing with optimizing corrosion control treatment.

Corrosion Control Treatment

The lead copper rule specifically states that all water systems serving over 50,000 people must conduct corrosion studies unless they can show that corrosion treatment is already optimized. These studies must compare the effectiveness of pH and alkalinity adjustment, calcium adjustment, and the addition of an orthophosphate or silica based corrosion inhibitor.

The corrosion treatment program in place is said to be optimized for large

systems when the difference between the source water and the 90th percentile (ranked best to worse) of tap water monitoring is less than .005 mg/L for two consecutive six month monitoring periods.

There are five main groups of inhibition techniques outlined by the EPA: alkalinity, pH, calcium (if carbonate stabilization is used), orthophosphate, and silica.

ALKALINITY. Alkalinity is a measure of the ability of a water to neutralize acids and bases. It is usually described by the relationship as follows: total alkalinity (TALK) = $[HCO_3^-] + 2[CO_3^{2-}] + [OH^-] - [H^+]$

As a general rule, low to moderate alkalinity decreases corrosion rates while higher alkalinities have been shown to increase the corrosion rates of copper and lead. Other constituents sometimes found or added to water supplies can also have an effect on alkalinity. The addition of orthophosphate, ammonia, silica, and hypochlorite will all serve to increase the alkalinity of a water. The bicarbonate and carbonate present effect many important reactions in corrosion chemistry including a water's ability to lay down a protective coating of calcium carbonate or complex films with other metals present.

The two most common methods used to increase alkalinity in water are the addition of either soda ash (Na_2CO_3) or sodium bicarbonate ($NaHCO_3$). These two products are also used to adjust the pH and should be used where both pH adjustment and an increase in alkalinity is desired.

Essentially, this technique relies on the ability of lead and copper to form precipitates of insoluble carbonates such as $Pb_3(CO_3)(OH)_2$ or Cu_2

$(CO_3)(OH)_2$. These precipitates form as films in the immediate proximity of where the corrosion of the lead or copper is occurring and serve to deposit a coating over the actively corroding area.

pH. The pH of the water plays a significant role in the ability of that water to deposit protective films on the surface of the water conduit. Many of the film forming mechanisms in corrosion protection methods are directly dependent upon maintaining a proper pH range. Most of the low solubility films such as lead carbonate will not form if the pH is too low. The same techniques used in increasing the alkalinity of a water supply will also serve to increase the pH of that same water. Both lime and caustic soda are additional agents commonly used to increase the pH of water. Care must be taken in the employment of this technique as increased pH values will also drive THM formation rates higher and result in a need for higher dosages of chlorine to achieve the same disinfecting properties found at a more neutral pH value.

CALCIUM. The formation of a calcium carbonate film—scale—is directly dependent upon the existence of sufficient calcium concentrations being available. Most waters contain enough naturally occurring calcium, obviating the need to add further amounts. The most cost effective method of adding calcium is by applying quicklime (CaO) which must be hydrated or slaked to $Ca(OH)_2$ before application.

ORTHOPHOSPHATE. The addition of orthophosphate is usually accomplished through the application of zinc orthophosphate. While the zinc found in zinc orthophosphate plays a less important role in the reduction of lead and copper corrosion, it plays a primary


role in the protection of other materials used in transporting water such as asbestos cement pipe, mortar lined pipe, cast iron, and galvanized surfaces. This inhibitor does not elevate the pH of the water. The primary mechanism by which corrosion protection is achieved by the addition of zinc orthophosphates is through the formation of lead phosphate and copper phosphate films. Such films tend to be insoluble, uniform, and tenacious, rendering a coating that stifles further corrosion.

It is important to note here the distinction between orthophosphates and polyphosphates, both of which are often lumped together and referred to generically as phosphates. Unlike orthophosphates, polyphosphates can sequester metals rendering them unavailable for use in forming a protective film. Often, this property will actually increase the corrosion rate of lead and copper by stripping the protective film from the surface of the corroding metal exposing

the surface of the metal to direct attack from the surrounding water. Orthophosphates, which do not exhibit this property, will not sequester metals and, in fact, serve to combine with those metals to form the protective films illustrated earlier. An additional property of polyphosphates is their tendency to revert to orthophosphates. Some protection when utilizing polyphosphates may thus be realized depending on the amount of reversion, and thus orthophosphate concentration, which has taken place.

SILICATES. Silicates, like zinc orthophosphates, perform the role of a corrosion inhibitor by combining with corrosion byproducts to form protective films over the corroding surface. While there has been a wealth of data accumulated supporting the effectiveness of inhibitors such as zinc orthophosphates, additional work needs to be done in looking at silicates as lead/copper corrosion inhibitors before the extent of their

effectiveness is fully known or understood. Initial work in comparing silicates against other treatment techniques looks promising and the employment of this technique has the further benefit of maintaining a more neutral pH environment as in the application of zinc orthophosphates without the addition of possible environmentally sensitive constituents such as zinc or phosphates into our water supplies.

CONCLUSIONS. There is no one answer available in making a selection of a particular treatment technique to reduce lead and copper corrosion rates. Many variables must be considered that will play a role in determining the best choice. While effectiveness of a particular treatment must play a primary role in this decision, other factors such as cost, byproducts (THMs), safety, and environment must also be considered before reaching a final conclusion. 

The preceding is courtesy of Sweetwater Technologies, www.sweetwatertech.com.